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Nutritional and Antinutritional Composition of *Sclerocarya birrea* Peels

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Abstract

The peels of *Sclerocarya birrea* were evaluated for its nutritional and antinutritional composition. The results show that the moisture, ash, crude protein, crude lipid, crude fibre, available carbohydrate and energy value were 67.55±0.23% weight wet, 10.21 ± 0.21 %, 8.33 ± 0.18 %, 2.42 ± 0.03 %, 6.56 ± 0.10 %, 72.47 ± 0.48 % and 345.05 ± 0.50 kcal/100g dry weight respectively. The result of minerals analysis showed that the peel is a good source of both macro and micro elements with calcium as predominant. The sample is a good source isoleucine. The concentrations of hydrocyanic acid, nitrate, oxalate and phytate were lower than the reference toxic standard level. The results indicate that if the peels are properly exploited and process, they could be a high quality and cheap source of carbohydrates and minerals supplement in the formulation of animal feeds.

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1. Introduction

Marula (*Sclerocarya birrea*) is one of the major wild plants in Sub-saharan Africa [1]. In Northern part of Nigeria is *Sclerocarya birrea* commonly known as "*Nunu*" or "*Loda*" or "*Daniya*" among the Hausa language [2]. Details botanical profiled of the tree has been reported [1, 3, 4,5]. The mature fruits (3-3.5cm in diameter) of *Sclerocarya birrea* are green but change to yellow when ripe. The fruit contain a white clinging flesh and a large stone from which the kernel can be obtained. Antinutritional composition and toxicological studies of *Sclerocarya birrea* fruit juice and seed kernel have been reported [6,7].

Traditionally, fruits of *Sclerocarya birrea*are eaten specifically in rural areas, the peels and the kernels are disposed in the fields or just thrown away, and with these the amount of the fruit wastes generated is increasing enormously. Large amount of these wastes poses the problems of disposal without causing environmental pollution. The peels discarded can be effectively disposed by manufacturing useful by- products from them.

Considering the upsurge in the prizes of livestock feeds and their increasing demand, this study was conducted to provide information on the nutritional and antinutritional composition of *Sclerocarya birrea* fruit peels which is often ignore and considered as waste, so that it could be domesticated for proper utilization as livestock feeds or as supplement in the formulation of livestock feeds.

2. Materials and Methods

2.1. Sampling and Sample Treatment

One kilogramme (1 kg) of matured and ripe *Sclerocarya birrea* fruits were collected in June, 2010 from More, Kware local government area of Sokoto State, Nigeria. Five (5) trees were randomly selected and the fruits were collected from different branches of the trees and representative sample was taken using alternate shovel method [8,9]. The juice, peels and seeds were separated by squeezing ripe fruits. The peels were air dried and pulverized to fine powder using pestle and mortar, sieved to pass through 80-meish sieve and stored in air tight paper bags inside a desiccator. The dried powder was used for the analysis other than moisture content in which fresh sample was used [10].

2.2. Proximate Analysis

Standards methods of AOAC [11] were used for the proximate analysis. The moisture content was determine by weighing two grammes (2g) of fresh peels in a crucible and dried in an oven (Gallenkamp, UK) at 105^oC for 24 hrs. The dried sample was then cooled in a desiccator for 30 minutes and weighed.

The ash content was determined by the incineration of 2g dried sample in a muffle furnace at 55^oC for 2hrs. Crude lipid (CL) was Soxhlet extracted from 2g dried sample with n-hexane for 8hrs.The nitrogen (N) content was estimated by micro-Kjeldahl method and crude protein (CP) content calculated as N% x 6.25. Crude fibre (CF) content was determined by treating 2g dried sample with 1.25% (w/v) H_2SO_4 and 1.25% (w/v) NaOH. The available carbohydrate (CHO) was calculated by difference. Calorific value (CV) was determined using the following equation [12]:

CV (kcal/100g) = (CHO x 4) x (CL x 9) x (CP x 4)

2.3. Mineral Analysis

Mineral analysis was carried out after sample digestion of 2g of the dried sample with $24cm^3$ mixture of nitric acid/perchloric/sulphuric acids in the ratio 9:2:1 respectively. Ca, Mg, Fe, Co, Mn, Cr, Ni, Cu and Zn were determined by atomic absorption spectrophotometry, Na and K by atomic emission spectrometry [11], and P by the molybdenum blue colorimetric method [13].

2.4. Amino acids Analysis

Duplicate samples were hydrolyzed by transferring 50mg of the sample into a 15ml ampoule, adding 5ml of 6M HCl, sealing the vial under vacuum, flushed with nitrogen, and digesting at 110^oC for 24 h. The sulphur-containing amino acids were determined using perfomic acid. Amino acids analyses were performed by high performance liquid chromatography (Shimadzu, G-C-14A, Kyoto, Japan) [14].

2.5. Antinutritional Analysis

The method of Ola and Oboh [15] was adopted for determination of phytate. Hydrocyanic acid was determined by the AOAC [11] method. Oxalate and nitrate were determined by the methods of Krishna and Ranjhan [16]. For determination of tannins the method of van-Burden and Robinson [17] was employed.

2.6. Statistical analysis

The data obtained was statistically analyzed using one-way analysis of variance (ANOVA) with SPSS version 10.0 statistical package and the results were reported as mean ± standard deviation of the values.

3. Results And Discussion

3.1. Proximate composition

The proximate composition of *Sclerocarya birrea* peel is presented in Table 1. The peel has moisture content of 67.55 ± 0.23% lower than 87.10% reported by Engelter and Wehmeyer [18]. High moisture content (84.33%) was also reported in the peels of *Hasta la pasta* fruits [19]. Higher moisture content is associated with a rise in microbial activities during storage [8], therefore, the samples should be properly dried before storing.

The peel has high ash contents (10.21 % dry weight) thus could be source of nutritionally important mineral elements. The value in within the range of 8.00 – 11.20 %DW reported in the peels of some tropical fruits [12].

The crude protein contents of the peel is appreciable (8.33 ± 0.18% DW) higher than 6.32% DW reported in the peels of African star-apple [20] also higher than 6.94% DW recorded in the peels of *Hasta la pasta* fruit [19]. Thus the peel could be an ingredient in compounding animal feeds.

The peel has low crude lipid contents (2.42 ± 0.03% DW). The value is lower than 8.33% DW reported in the peels of *Hasta la pasta* fruit [19] but higher than 1.25% DW in the peels of African star-apple [20]. This is expected as most fruits are generally known for their low lipid contents [12], as a result of this it could be used in body weight control.

The analyzed sample has crude fiber contents of 6.56 ± 0.10% DW which is higher than 1.25% DW reported for African star-apple [20], but lower than 8.33% DW reported in the peels of *Hasta la pasta* fruits [19]. High fiber content in food causes intestinal irritation and lower nutrient availability [21]. It was reported that consumption of vegetable fiber can reduce serum cholesterol level, risk of coronary heart disease, hypertension, and also enhances glucose tolerance and increase insulin sensitivity [8]. Thus, the fruit is a good source of dietary fiber and has the potential of providing body requirements of fiber.

The peels have available carbohydrate content of 72.47 ± 0.48% DW. The value recorded is lower compared to 77.43% DW and 80.06% DW reported in the peels of African star-apple and *Hasta la pasta* fruits [19,20] reported by Leakey [20].The main function of carbohydrates is to provide energy. In view of its high carbohydrate contents the peels could be used to supplement carbohydrate in the formulation of animal feeds.

The peel calorific value 345.05 ± 1.50% DW is lower than 1540kcal/100g DW reported for the peels of *Hasta la pasta* fruits [19], but is in agreement with 345.25kcal/100g DW in the peels of African star-apple [20]. The observed value indicate that the peels can contribute 5.16% of 6691 kJ set as recommended daily intakes [22]. The value recorded, however, is lower than the adult energy requirement (3000kCal/day) [23].

Table 1: Proximate Composition of *Sclerocarya birrea* Peels (g/100g DW)

Parameters	Concentration
Moisture*	67.55 ± 0.23
Ash	10.21 ± 0.21
Crude protein	8.33 ± 0.18
Crude lipid	2.42 ± 0.03
Crude fibre	6.56 ± 0.10
Available carbohydrate	72.47 ± 0.48
Calorific value**	345.05 ± 1.50

The data are mean value ± standard deviation of three replicates

* Value expressed as % wet weight. ** The unit is kcal/100g

3.2 Elementals composition

The minerals profile of the Peels is reported per 100g and the result presented in Table 2. Calcium is the most abundant (447.40 ± 0.51mg) element in the peel followed by potassium (216.43 ± 3.31mg) and then sodium (38.23 ± 1.33mg). Calcium is important in the proper development of bones and teeth while potassium and sodium are important body electrolytes. The contents of iron and copper were 4.18 and 0.87mg respectively, and were lower than 4.27mg and 2.77mg reported in *S. Birrea* seed kernel [2]. The peels also contain a reasonable amount of manganese (0.64 ± 0.40mg), nickel (0.43 ± 0.32mg), zinc (13.54 ± 0.21mg) and chromium (1.78 ± 0.03mg). The concentration of cadmium and lead in the peel (0.19 ± 0.01mg and 0.20 ± 0.01mg) are below the toxic level of 0.2mg/100g and 0.3mg/100g known to cause cadmium and lead toxicity respectively [24]. The result indicates that the peel could supplement the body with both macro and microelements.

Table 2: Elementals Composition of *Sclerocarya birrea* Fruit (mg/100g DW)

Mineral element	Concentration
Na	38.23 ± 1.33
K	216.43 ± 3.31
P	0.27 ± 0.01
Ca	447.40 ± 0.51
Mg	6.33 ± 0.34
Mn	0.64 ± 0.40
Fe	4.18 ± 0.31
Co	1.63 ± 0.10
Ni	0.43 ± 0.32
Cr	1.78 ± 0.03
Zn	13.54 ± 0.21
Cu	0.87 ± 0.30
Cd	0.19 ± 0.01
Pb	0.20 ± 0.01

The data are mean ± standard deviation of triplicates results

3.3. Amino acids profile

The amino acids composition of the peel is presented in Table 3a. The result indicates that, the essential amino acids content was 38.0% while the non-essential amino acids content was 62.0%. Leucine is the predominant essential amino acids accounting for 5.08 ± 0.11%. On the non-essential amino acids, glutamic acid is the predominant (12.00 ± 4.24%) and this is in agreement with that of *Hasta la pasta* fruits [19].

To evaluate the nutritional quality of the peels in terms of amino acids profile. The percentage essential amino acids in the peels were compared with the WHO ideal protein (Table 4). From the results, it is clear that the peel is of **low quality in terms of essential amino acids requirement as it is only rich in some of isoleucine.**

Table 3: Amino Acids Composition of the Peels (g/100g protein)

Amino acids	Concentration
Cystine (Cys)*	0.48 ± 0.12
Lysine(Lys)*	4.01 ± 0.13
Valine (Val)*	3.33 ± 2.10
Methionine (Met)*	1.07 ± 0.81
Isoleucine (Ile)*	3.45 ± 1.80
Leucine (Leu)*	5.08 ± 0.11
Tyrosine (Tyr)*	1.44 ± 0.15
Threonine (Thr)*	3.05 ± 1.51
Phenylalanine (Phe)*	3.08 ± 1.50
Total essential	**24.99**
Proline (Pro)	3.25 ± 0.21
Glycine (Gly)	2.97 ± 0.13
Alanine (Ala)	4.53 ± 2.80
Histidine (His)	2.33 ± 1.44
Arginine (Arg)	4.64 ± 2.82
Aspartic acid (Asp)	8.65 ± 1.81
Serine (Ser)	2.36 ± 0.50
Glutamic acid (Glu)	12.00 ± 4.24
Total non-essential	**40.73**

The data are mean value ± standard deviation of three replicates * Essential Amino acids

3.4. Antinutritional factors

The result of antinutritional factors was presented in Table 5. Tannin is the most abundant antinutrient in the peel followed by phytate and then oxalate. Tannin is responsible for the astringent flavour of the fruit and has adverse effect on health through inhibition of protein digestion [25].

The phytate content in the peels (214.72 ± 3.76mg/100gDW) is higher compared to 4.17mg/100g DW for the peels of *Hasta la pasta* fruits [19]. Phytate is a major component of plant storage organs where it serves as phosphate source for germination and growth [26]. Phytate bind minerals in the gastrointestinal tract, making dietary minerals unavailable for absorption and utilization in the body [27]. It decreases calcium bioavailability and form calcium phytate complexes that inhibit the absorption of iron and zinc [28].

Table 4: Essential amino acids composition compared to the WHO ideal protein

Amino acid	**Amount (g/100g protein)**	**WHO Ideal Value**	**Chemical Score (%) [amino acid/ideal] x 100**
Isoleucine	3.45	2.8	123
Leucine	5.08	6.6	77
Lysine	4.01	5.8	69
Methionine + Cystine	1.55	2.5	62
Phenylalanine + Tyrosine	4.52	6.3	72
Threonine	1.44	3.4	42
Valine	3.33	3.5	95

The total oxalate content in the analyzed sample is 90.49 ± 0.65mg/100gDW. The value recorded in the peels is high compared to 16.87mg/100g DW in the peels of *Hasta la pasta* fruits [19]. Oxalate and its contents have deleterious effect on nutrition and health, mainly by decreasing calcium and magnesium absorption and aiding the formation of kidney stone [26].

The analysed sample has hydrocyanic acid content of 21.66 ± 0.81mg/100g DW. The value is higher than 0.5mg/100g DW in the peels of *Hasta la pasta* fruits [19] but lower than 35mg/100g DW which is reported as toxic level [29]. Hydrocyanic acid affects blood hemoglobin making it unavailable for transporting oxygen [28]. Lower dose may cause dizziness and headaches [30].

The concentration of nitrate in the analyzed peel (0.54 ± 0.11mg/100g DW) is low compared to 3.5mg/100g DW in the peels of *Hasta la pasta* fruits [19]. The value is low compared to the recommended daily intakes of 77 mg and also lower than the acceptable daily intake level of 3 – 7mg/kg body weight equivalent of 220mg for a 60kg person [31].

To predict the bioavailability of calcium, magnesium, zinc and iron, antinutrients to nutrients molar ratios were calculated and the results presented in Table 6. From the results, oxalate does not have any effect on the elements bioavailability but phytate caused impaired iron bioavailabiliy in the body. To enhance iron bioavailability the peel should be consumed with the fruit juice so as to bust vitamin C intake.

Table 5: Antinutritional Composition of *Sclerocarya birrea* Fruit (mg/100g DW)

Parameters	Concentration
Phytate	214.72 ± 3.76
Tannins	1817.00 ± 5.70
Total oxalate	90.49 ± 0.65
Hydrocyanic acid	21.66 ± 0.81
Nitrate	0.54 ± 0.11

The data are mean value ± standard deviation of three replicates

Table 6: Antinutrients to Nutrients Molar ratio

Antinutrients to Nutrients ratio	Ratio	Critical level
[Oxalate] / [Ca]	8.9×10^{-1}	2.5
[Oxalate]/[Ca+ Mg]	7.25×10^{-1}	2.5
[Ca][Phytate] / [Zn]	1.76×10^{-3}	0.5
[Phytate] / [Ca]	2.9×10^{-1}	0.2
[Phytate] / [Fe]	4.4	0.4
[Phytate] / [Zn]	1.57	10

4. Conclusion

The results have revealed that the peel is potentially a good source of some essential mineral elements especially calcium, potassium, sodium and magnesium which are found in high concentration. The antinutrients to nutrients molar ratio indicate that the peels of *Sclerocarya birrea* fruits are relatively safe for consumption and can be used as a supplement in the formulation of animals feed.

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